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Supercomputing  
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*Centro Nacional de Supercomputación*



# EC-Earth Climate Prediction Working Group

Etienne Tourigny

and the Climate Prediction Group at BSC

V. Guemas, F. Doblas-Reyes, R. Bilbao, O. Bellprat L.  
Brodeau, R. Cruz-García, E. Exarchou, N. Fučkar, J. García-  
Serrano, M. Ménégos, C. Prodhomme, V. Sicardi, F.  
Massonnet, J.C. Acosta Navarro



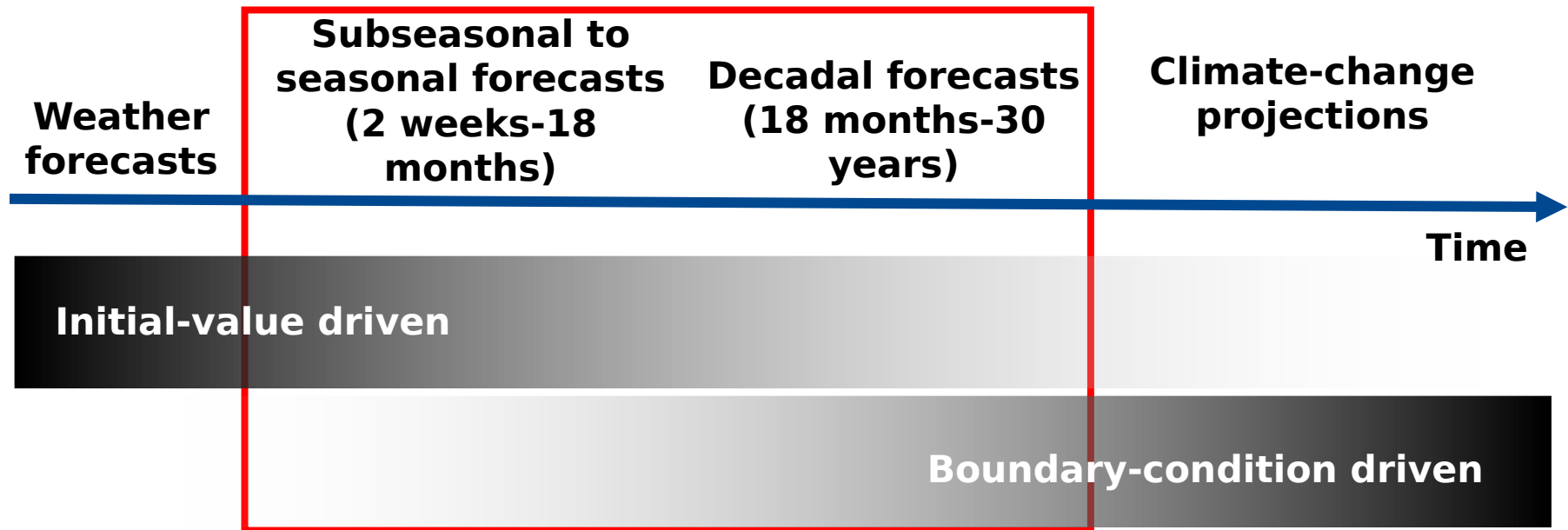
- Climate prediction with EC-Earth
- Initial conditions for CP
- CMIP6 plans at BSC CP Group
- DCP

- [https://dev.ec-earth.org/projects/ecearth3/wiki/Climate\\_Prediction\\_Working\\_Group](https://dev.ec-earth.org/projects/ecearth3/wiki/Climate_Prediction_Working_Group)
- WG mailing list : [ecearth.climate.prediction@bsc.es](mailto:ecearth.climate.prediction@bsc.es)
- Terms of reference
  - To **tune** the EC-Earth 3.2 version in standard and high resolutions in **seasonal prediction mode**
  - Coordinate the participation of the EC-Earth consortium to **DCPP**
  - Develop **initialization** and ensemble generation techniques, **share initial conditions** to others
  - Assess climate forecast **quality** on sub-seasonal to decadal timescales
  - Investigate **sources and mechanisms** of predictability
- Experimental protocol for tuning in seasonal prediction mode
  - Run 5-member 4-month-long seasonal predictions initialized Nov. from 1993 to 2009
  - One 10-year-long simulation to be run by BSC at the end of the tuning process
- Repository for initialization, ensemble generation and verification tools
- Repository for initial conditions

# Climate prediction time scales



Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (**sub-seasonal, seasonal and decadal**) in the middle. Prediction involves initialization and systematic comparison with a **simultaneous** reference.

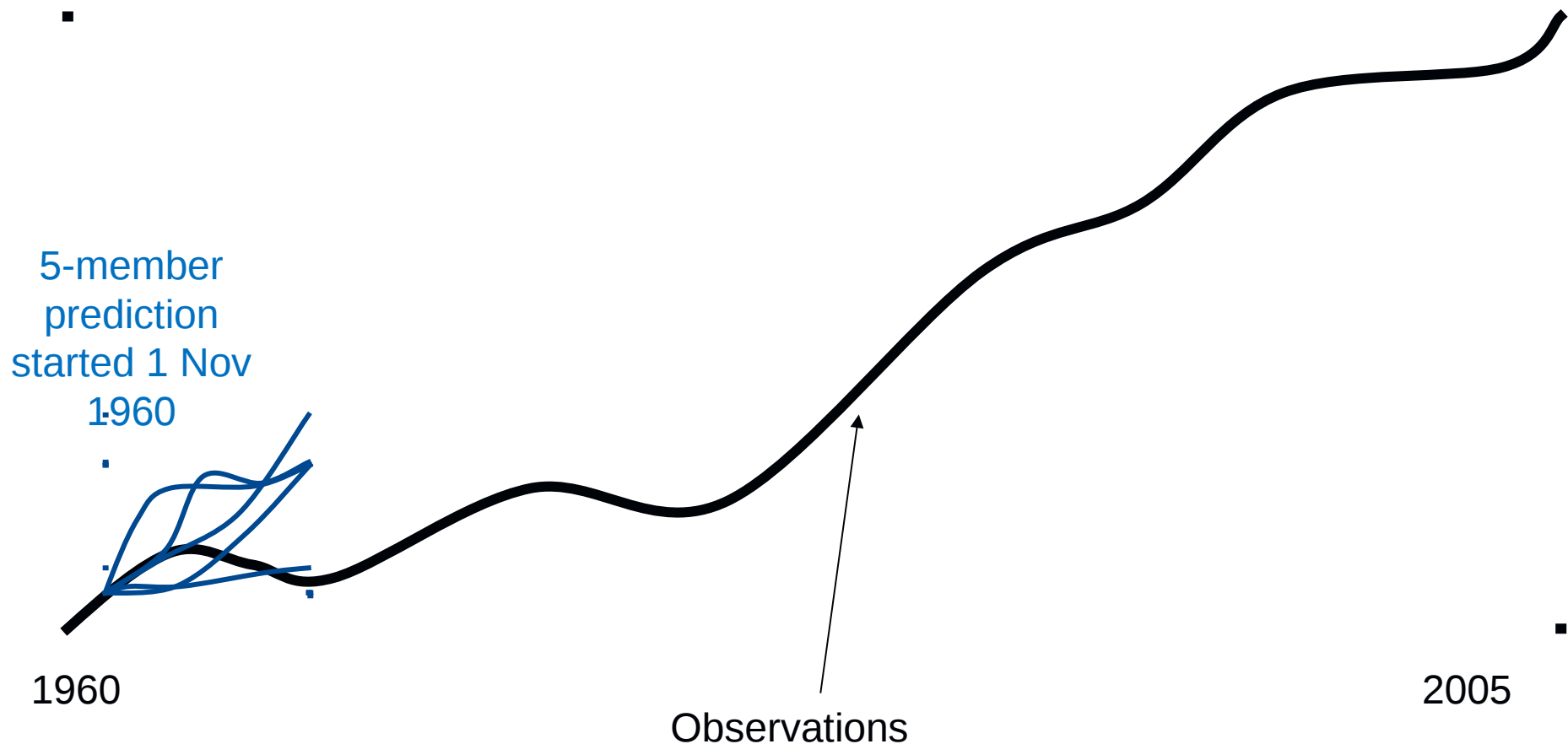


Adapted from Meehl et al. (2009)

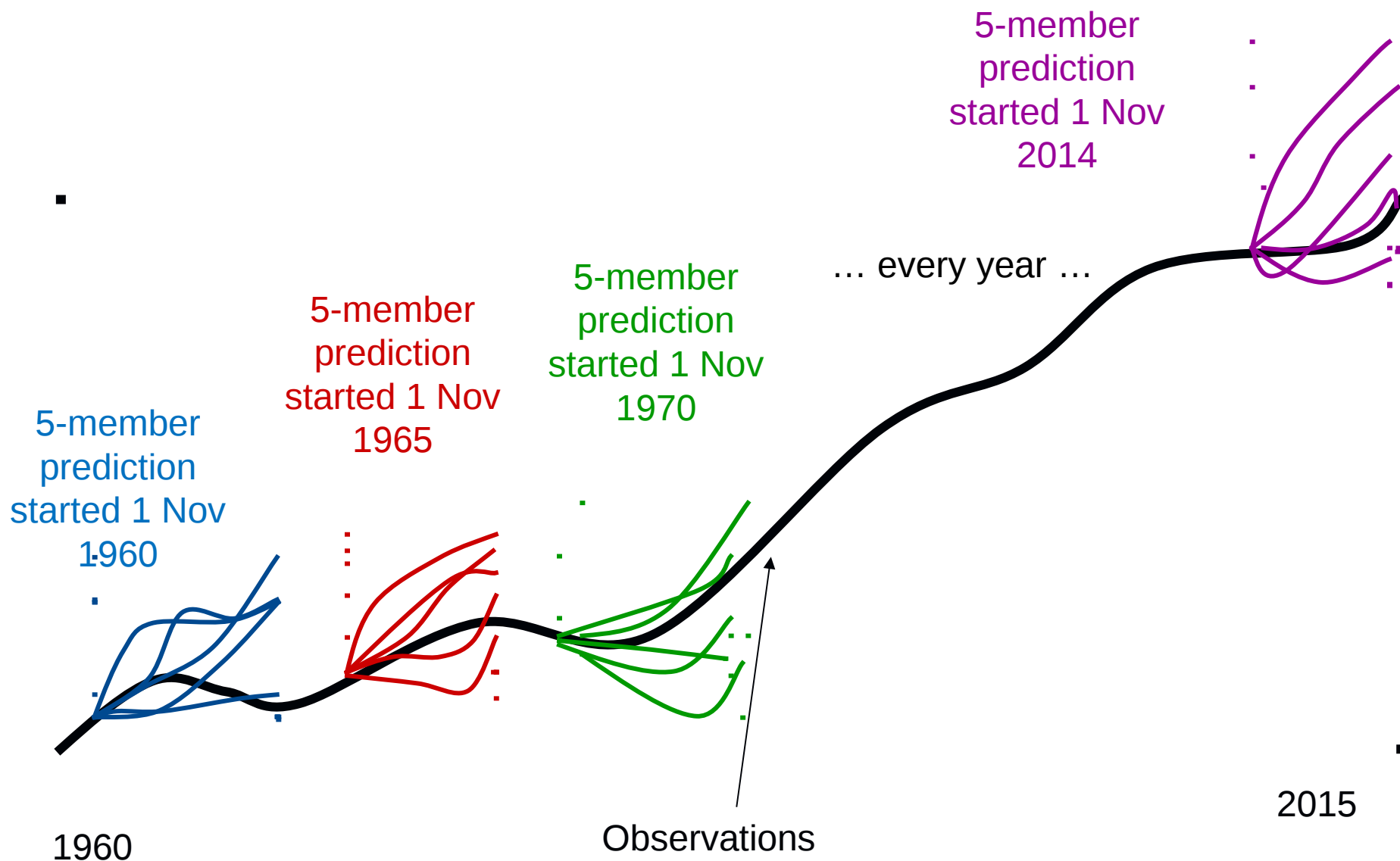
# Climate prediction experiments



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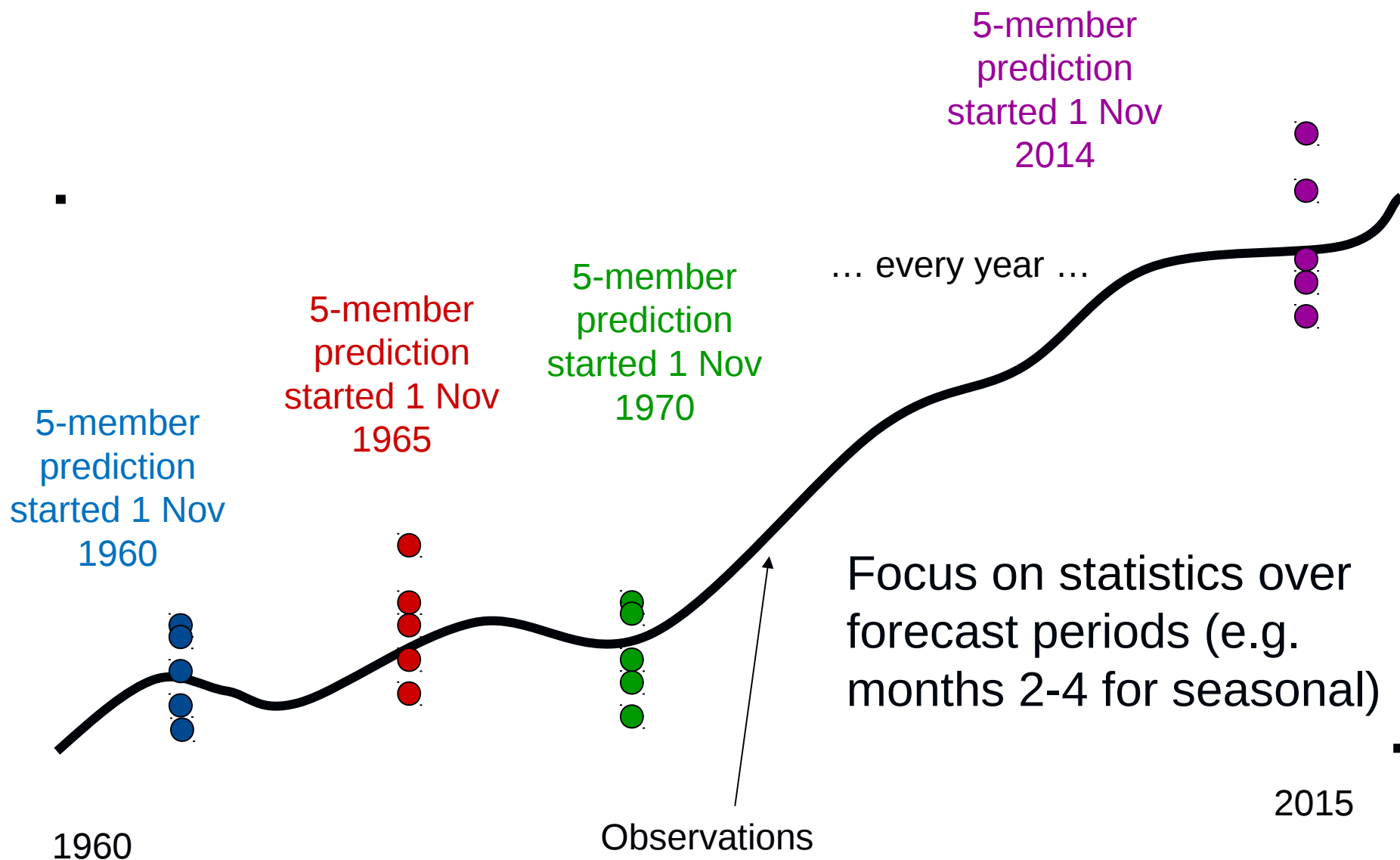
# Climate prediction experiments



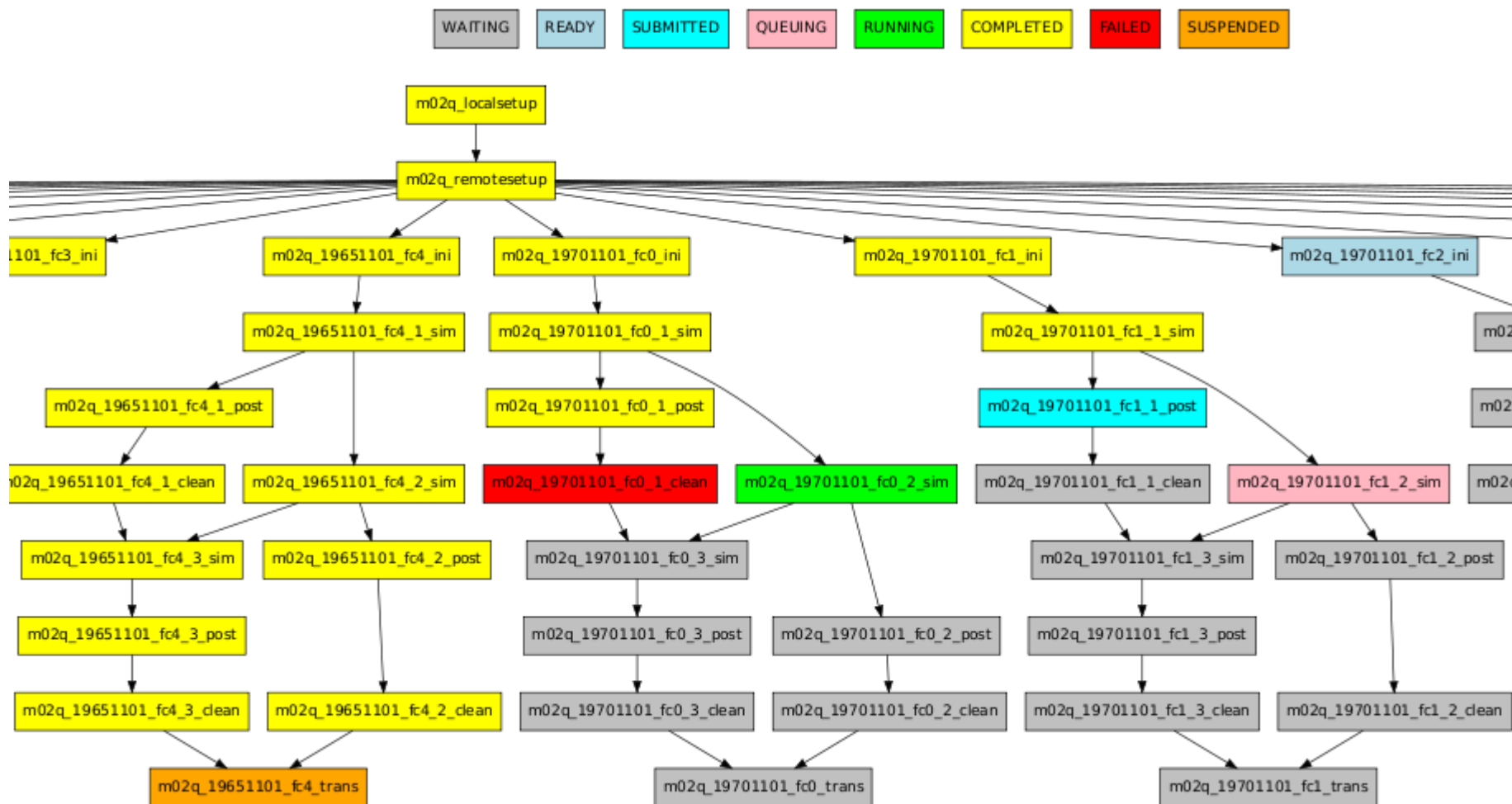
# Climate prediction experiments



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# Climate Prediction Workflow

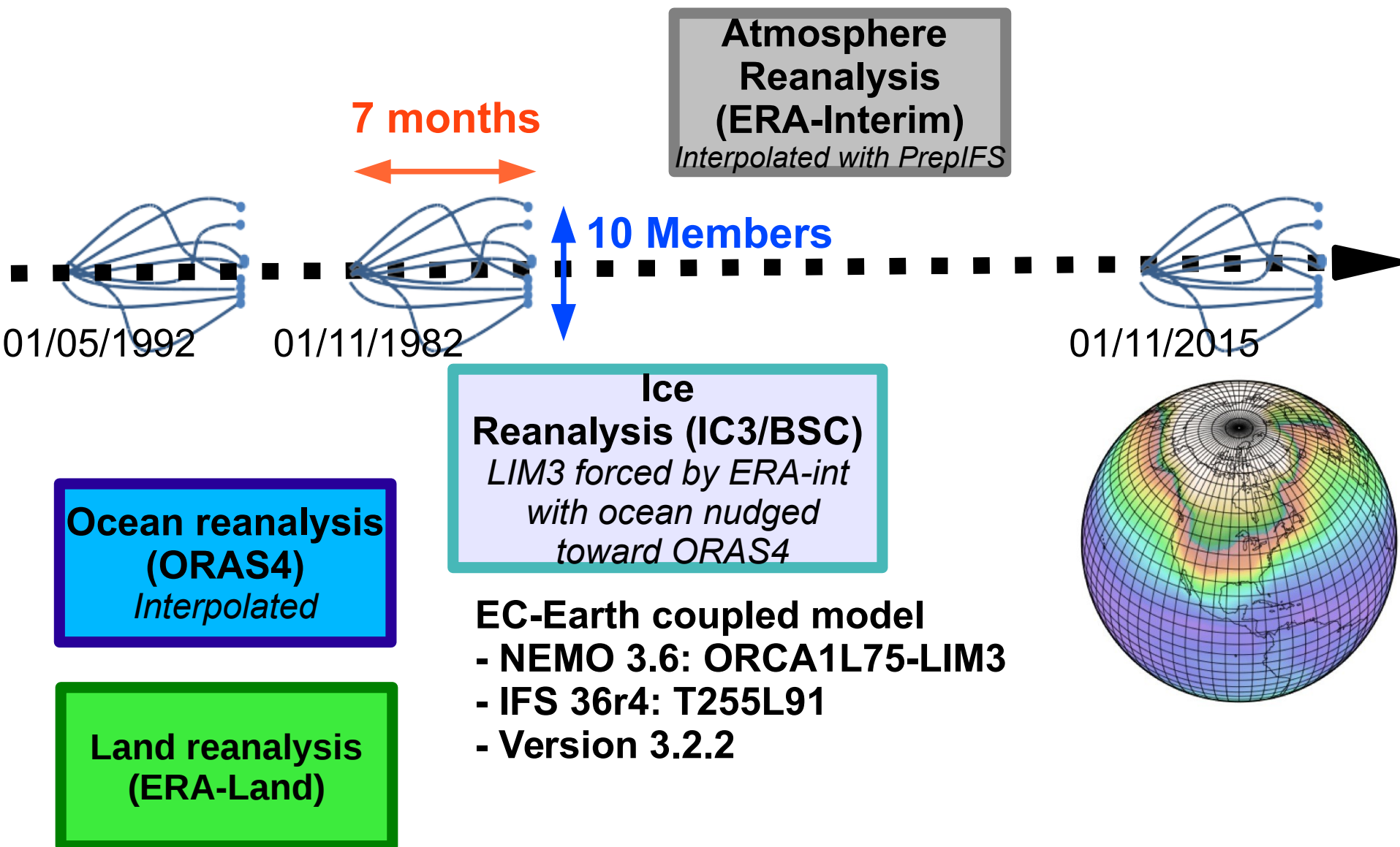




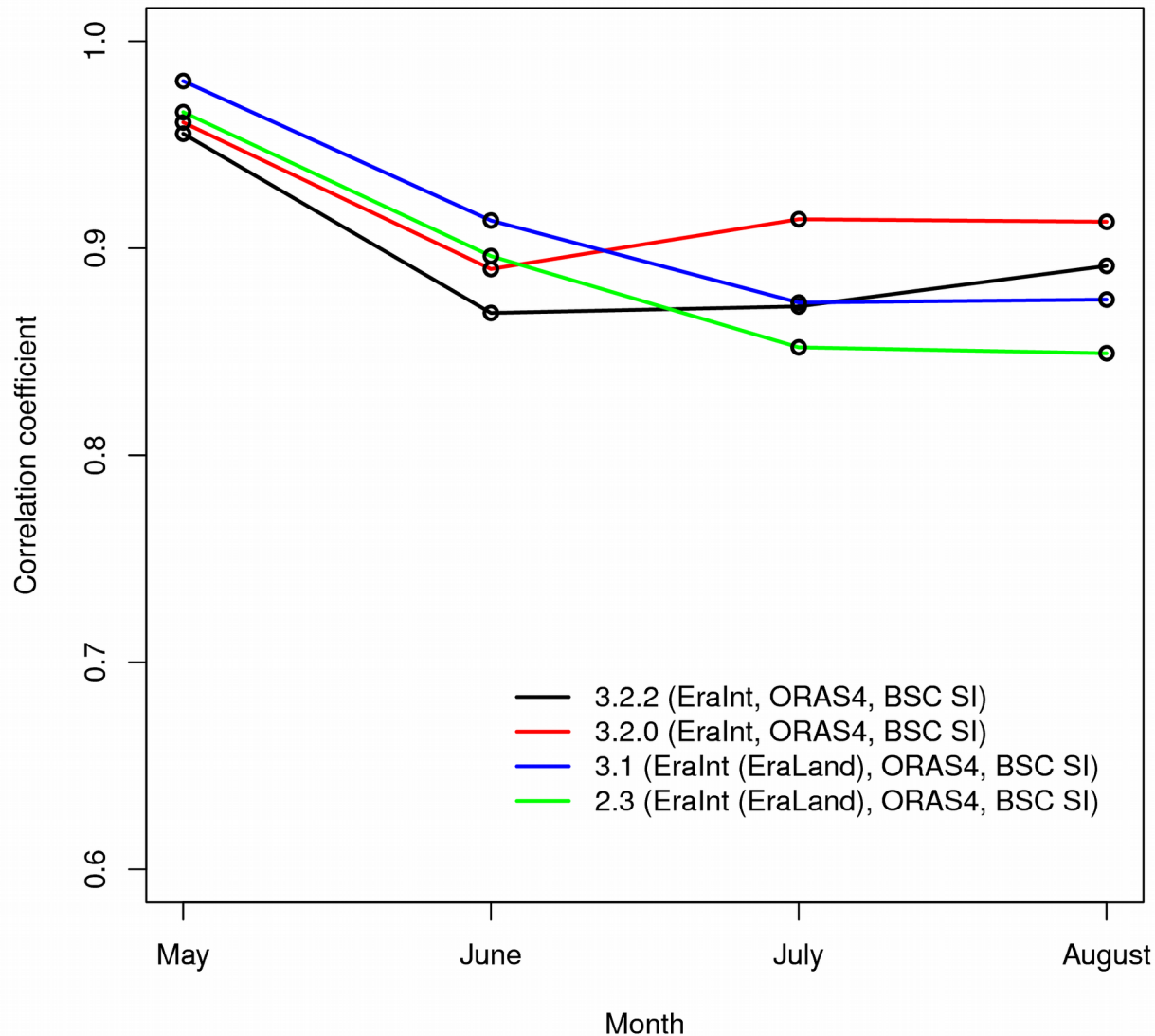
# Forecasts with EC-Earth 3.2.2



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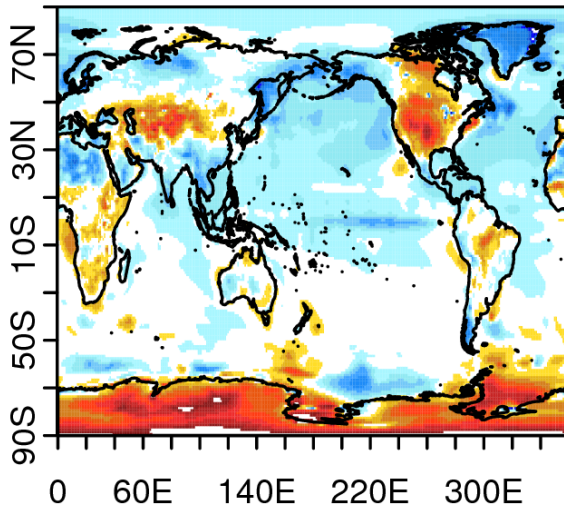
EC-Earth Nino3.4 Skill (1993-2009) (HadISST)



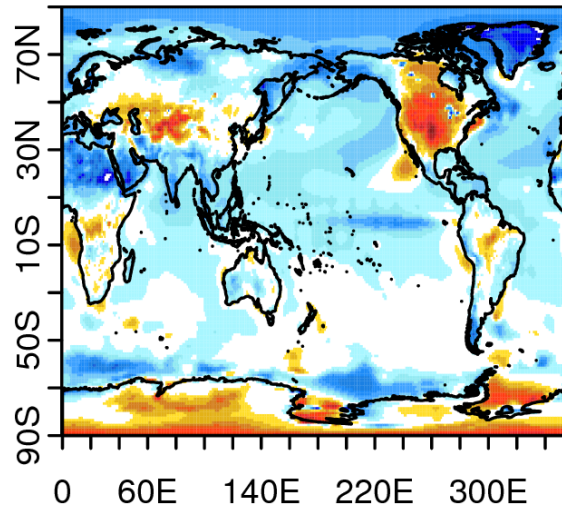
# JJA (1993-2009) SAT bias (°C)



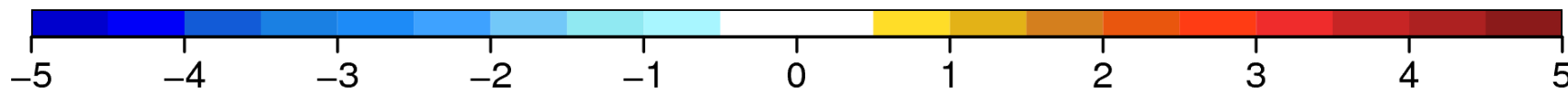
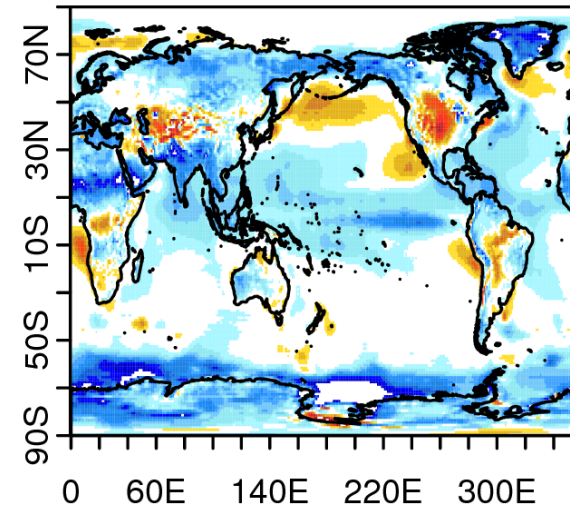
EC-Earth3.2.2 (CMIP6)



EC-Earth3.2.0



EC-Earth2.3 (CMIP5)

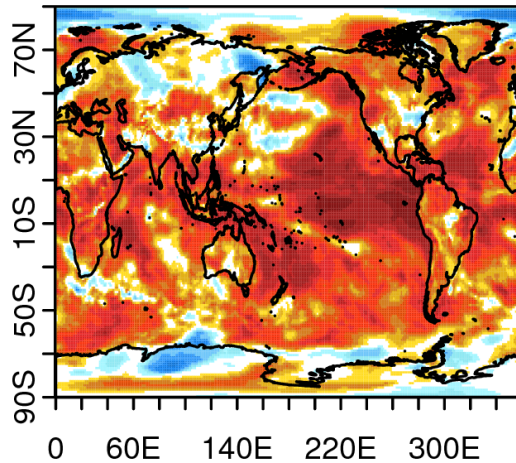




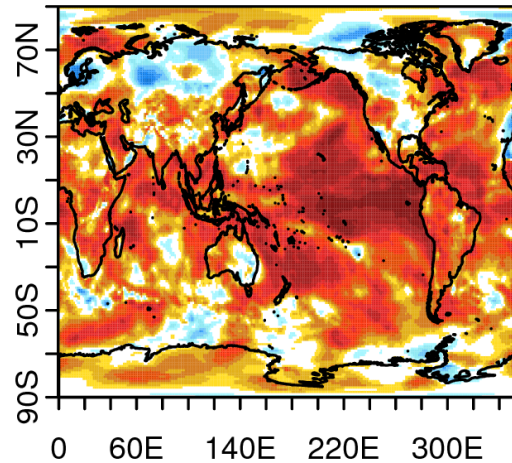
# JJA (1993-2009) SAT skill



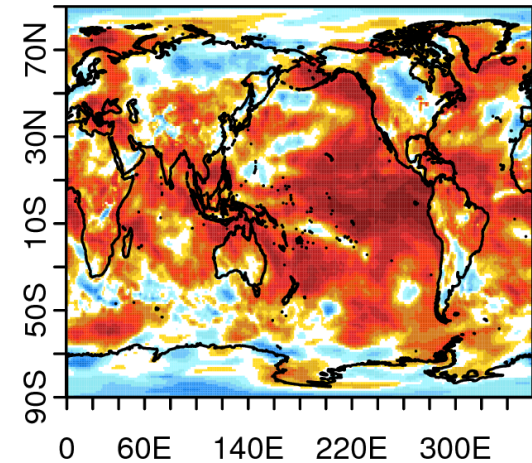
EC-Earth3.2.2 (CMIP6)



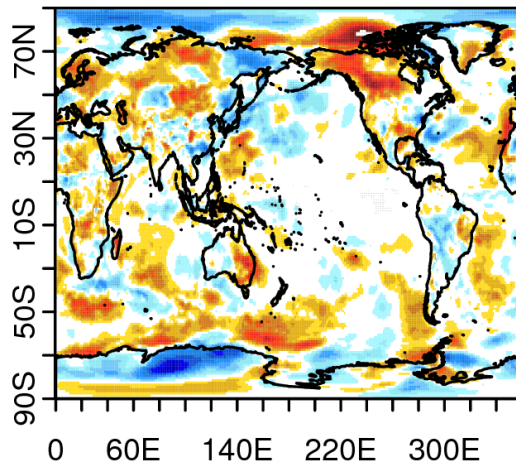
EC-Earth3.2.0



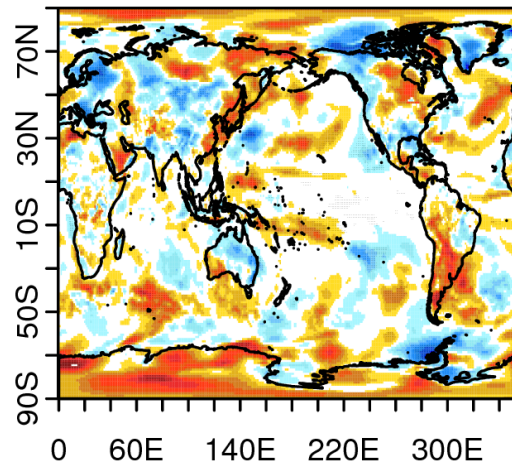
EC-Earth2.3 (CMIP5)



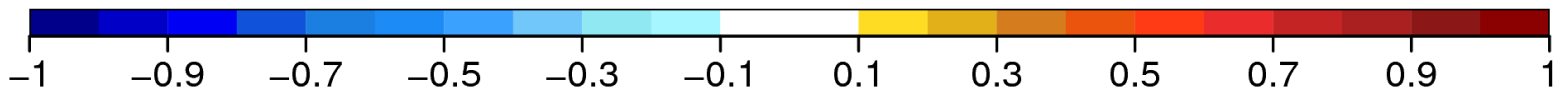
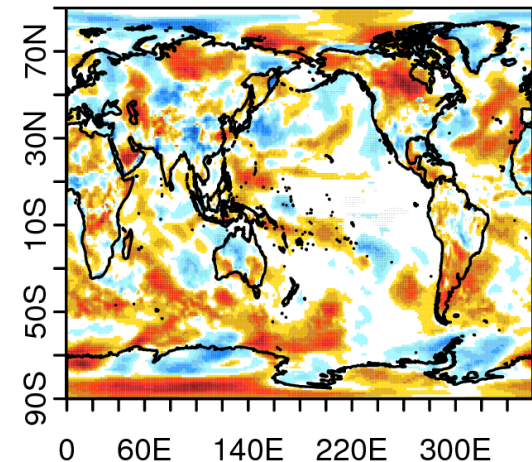
Correlation Diff (EC3.2.2-EC3.2.0)



Correlation Diff (EC3.2.0-EC2.3)



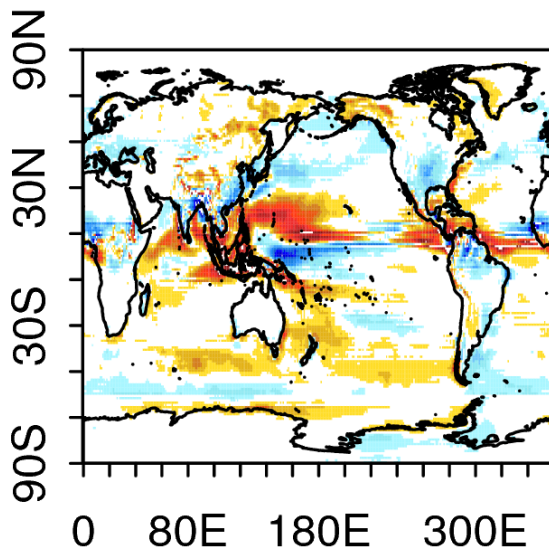
Correlation Diff (EC3.2.2-EC2.3)



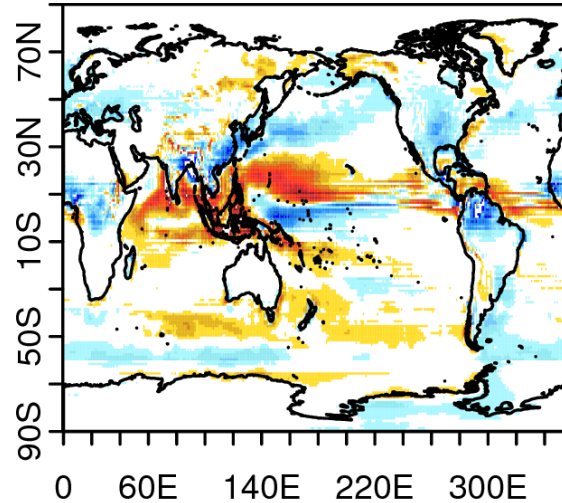
# JJA (1993-2009) Precip. Bias (mm/day)



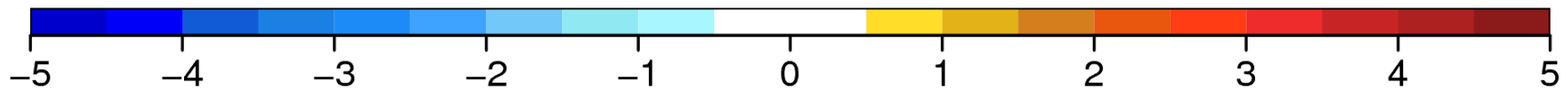
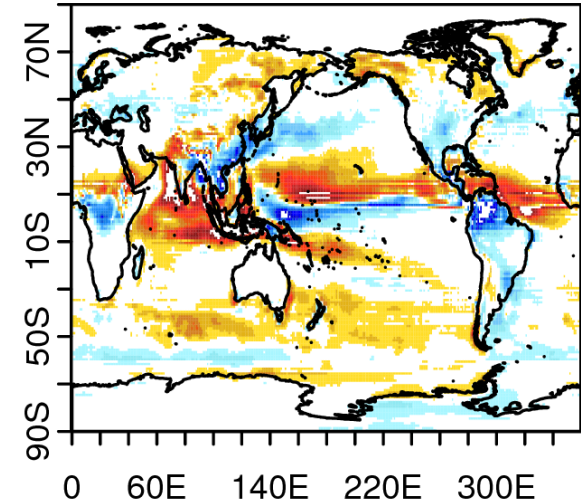
EC-Earth3.2.2



EC-Earth3.2.0



EC-Earth2.3

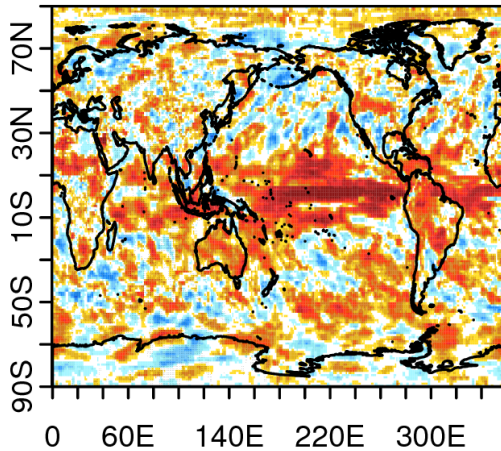




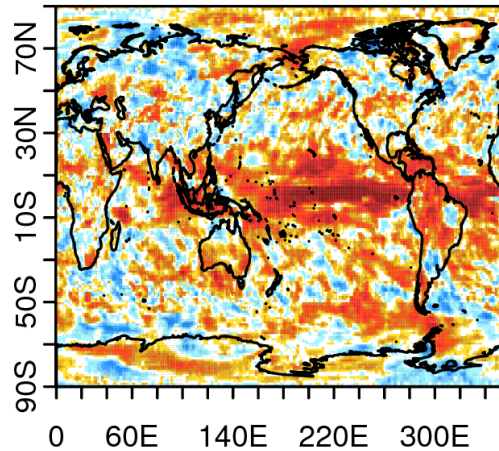
# JJA (1993-2009) Precip. Skill



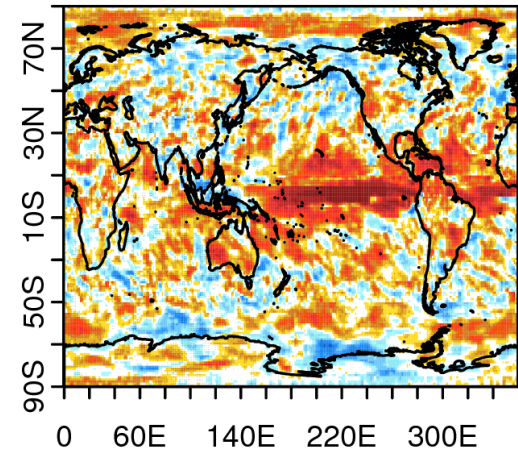
EC-Earth3.2.2 (CMIP6)



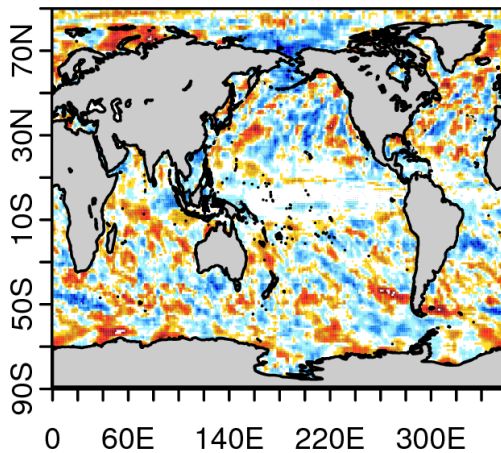
EC-Earth3.2.0



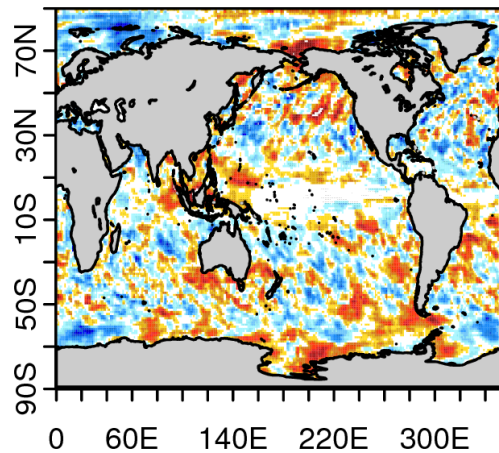
EC-Earth2.3 (CMIP5)



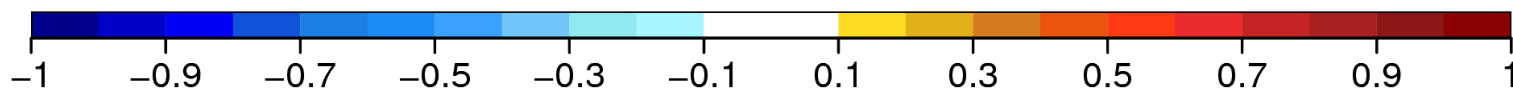
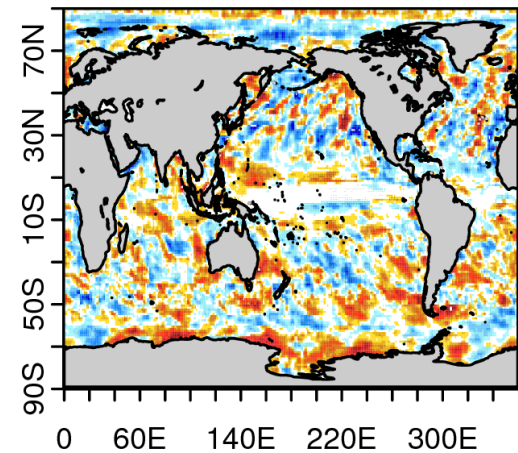
Correlation Diff (EC3.2.2-EC3.2.0)



Correlation Diff (EC3.2.0-EC2.3)



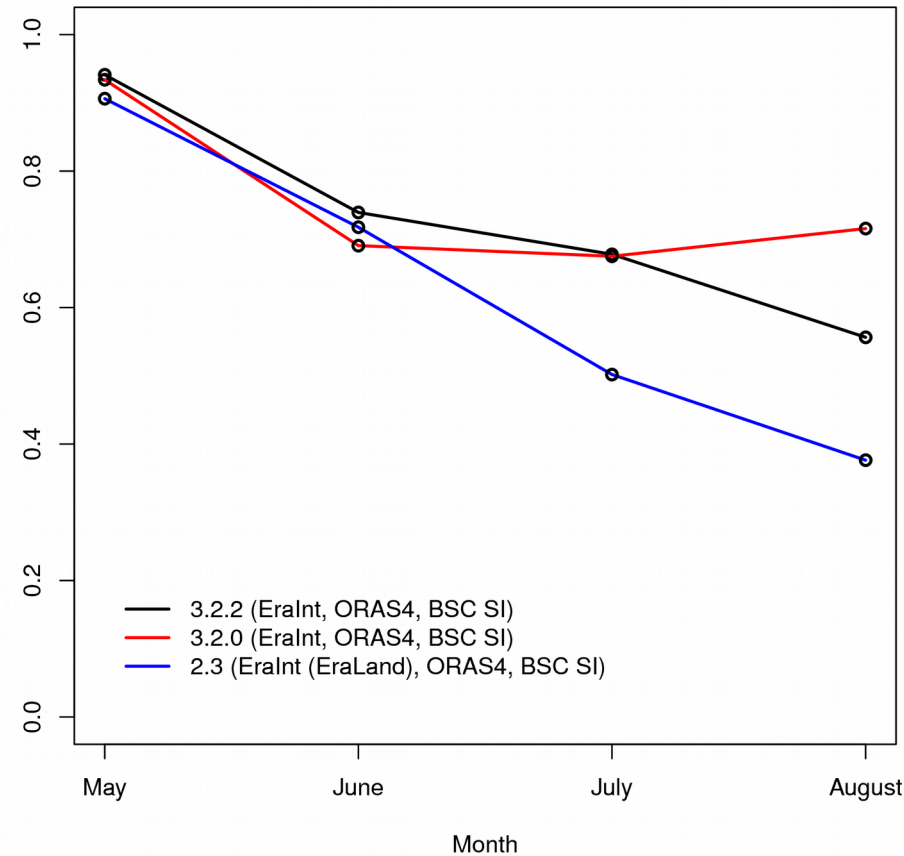
Correlation Diff (EC3.2.2-EC2.3)



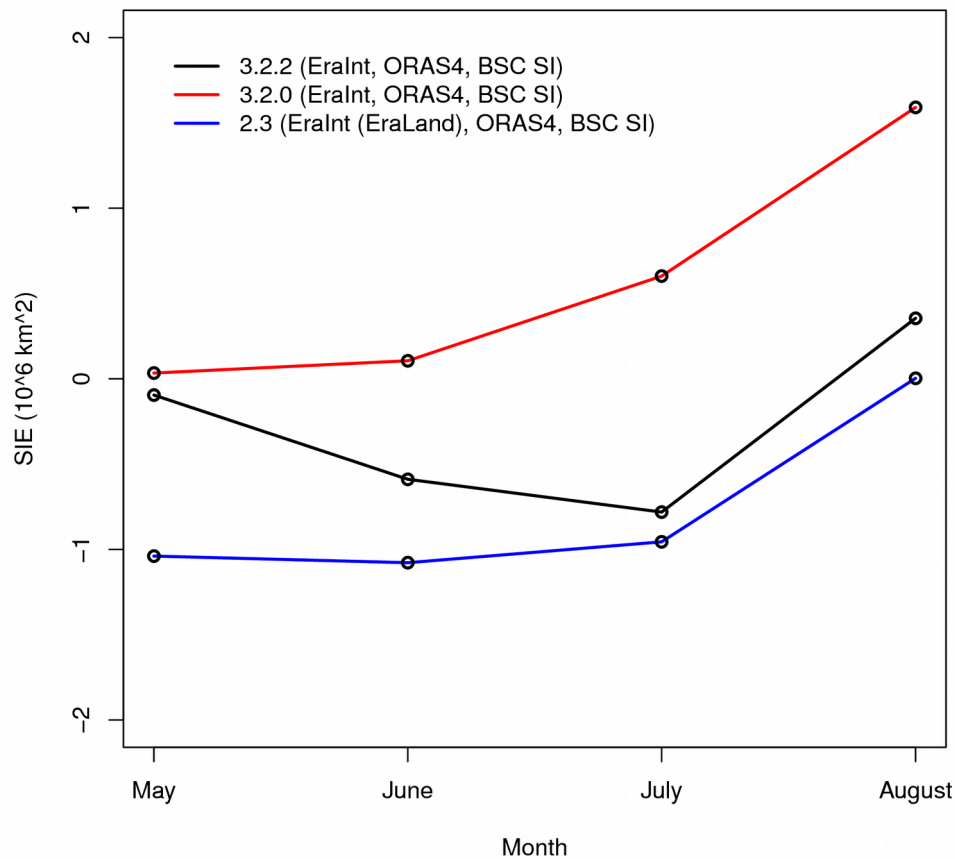
# JJA (1993-2009) Arctic Sea Ice extent



EC-Earth NH SIE Skill (1993–2008) (NSIDC)



EC-Earth NH SIE Bias (1993–2008) (NSIDC)



- Atmospheric initial conditions generated using FULLPOS for three different resolutions of IFS. FULLPOS conducts a physical interpolation and therefore ensures little model drift.
- We are investigating how to generate these without relying on prepIFS, open to suggestions!!!
- The initial conditions are prepared for many periods:
  - 1960 - 2015 using ERA-40 (1960-1978)
  - ERA-Interim (1979-2015)
  - ERA-Land (1979-2015) - forced by GPCP, replaces surface model fields
- 10-member (SST perturbation), Start dates each year in February, May, August, November



- Ocean:
  - ORAS4 interpolated/extrapolated 5-member restarts in the configuration ORCA1L75 covering the 1958-2013 period, at ECFS `ec:/c3y/restarts_ORAS4`
  - Many more available, and more can be produced easily
- Sea Ice:
  - 5-member ORCA1 reconstructions
  - 1-member ORCA1 and ORCA025 reconstructions
  - 24-member ORCA1 reconstructions with sea ice data assimilation (done using NEMO or EC-Earth)
  - ORCA025 reconstruction under development
  - Work by F. Massonet and N. Fuckar

# Generation of sea ice initial conditions with the Ensemble Kalman Filter

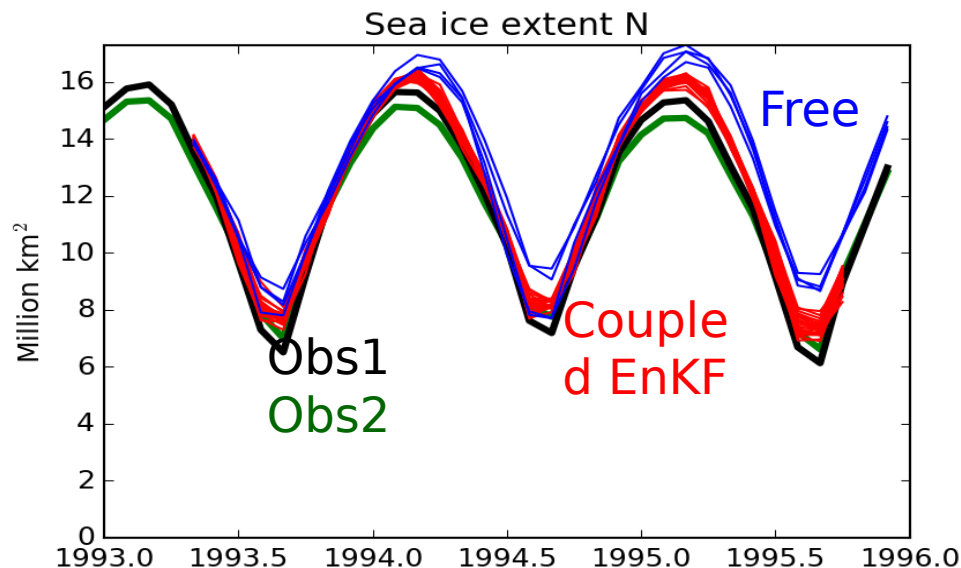
François  
Massonnet  
(UCL/BSC)  
N. Fučkar  
(BSC)

- A 25-member reanalysis, spanning 1979-2015 was generated at BSC
  - ☾ Using NEMO3.6 in stand-alone configuration (forced by atm. rean.)
- Besides, a coupled reanalysis has successfully tested for few years at ORCA1
  - We wait for a tuned EC-Earth3.2 CMIP6 version to produce the same period with coupled EnKF reanalysis
- A high-resolution (ORCA025) version of the reanalysis is currently under implementation (N. Fučkar)

The advantage of using these improved initial sea ice conditions has not been tested yet. Therefore, DCPP will be run using historical nudging/restoring reconstructions carried out at BSC (N. Fučkar).

# Generation of sea ice initial conditions with the Ensemble Kalman Filter in EC-

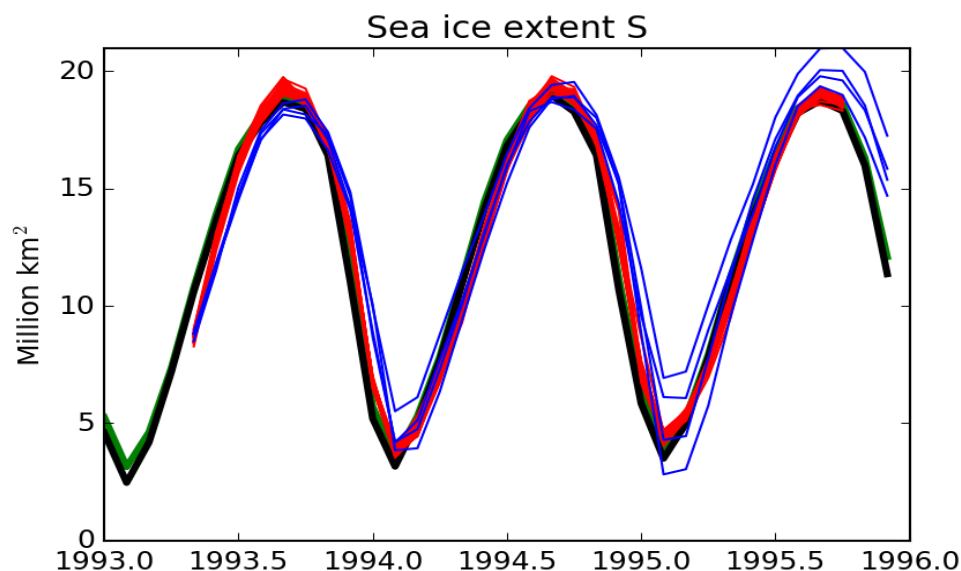
François  
Massonnet  
(UCL/BSC)  
N. Fučkar  
(BSC)



**NH SIE**

A prototype coupled data assimilation scheme has been developed

- SIC is assimilated monthly in EC-Earth3.2
- The EnKF provides a good constraint on sea ice extent

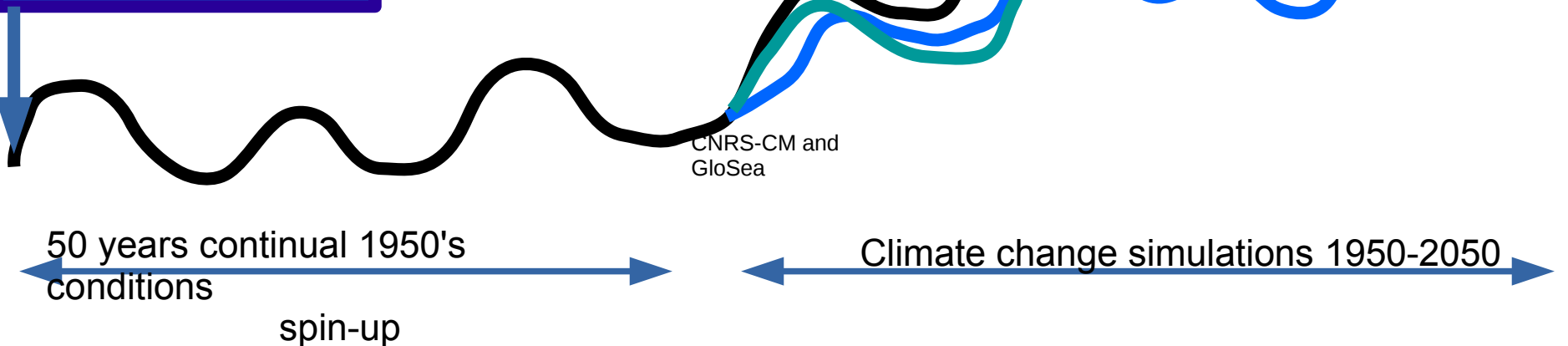


**SH SIE**

- HighResMIP + PRIMAVERA : 50yr spinup + 1950-2050 control+historical
- DCPP components A+B+C (more later)
- stratospheric aerosol forcings + volMIP (M. Ménégoz)
- SIMIP : Sea-ice ICs with Ensemble Kalman filter (EnKF)
- Reproducibility Protocol
- ESGF node for storage of PRIMAVERA and DCPP experiments (P-A Bretonniere)

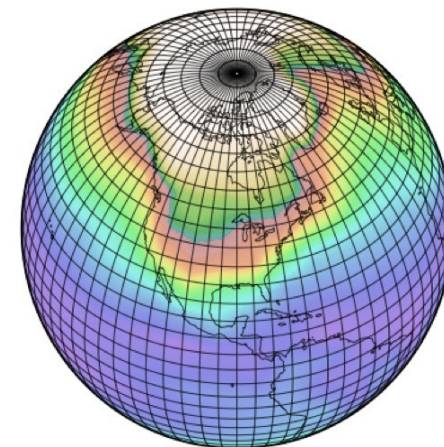
This protocol consists in a 50-year spin-up from the EN4 observational database under 1950 conditions followed by a 3-member 1950-2050 simulation. AWI-CM and EC-Earth will be employed. MET Norway considers participation in this task on an in kind basis, if technical aspects have been addressed when the experiments will start.

**Ocean initial  
conditions:  
EN4 interpolated**



**EC-Earth coupled model High Resolution**

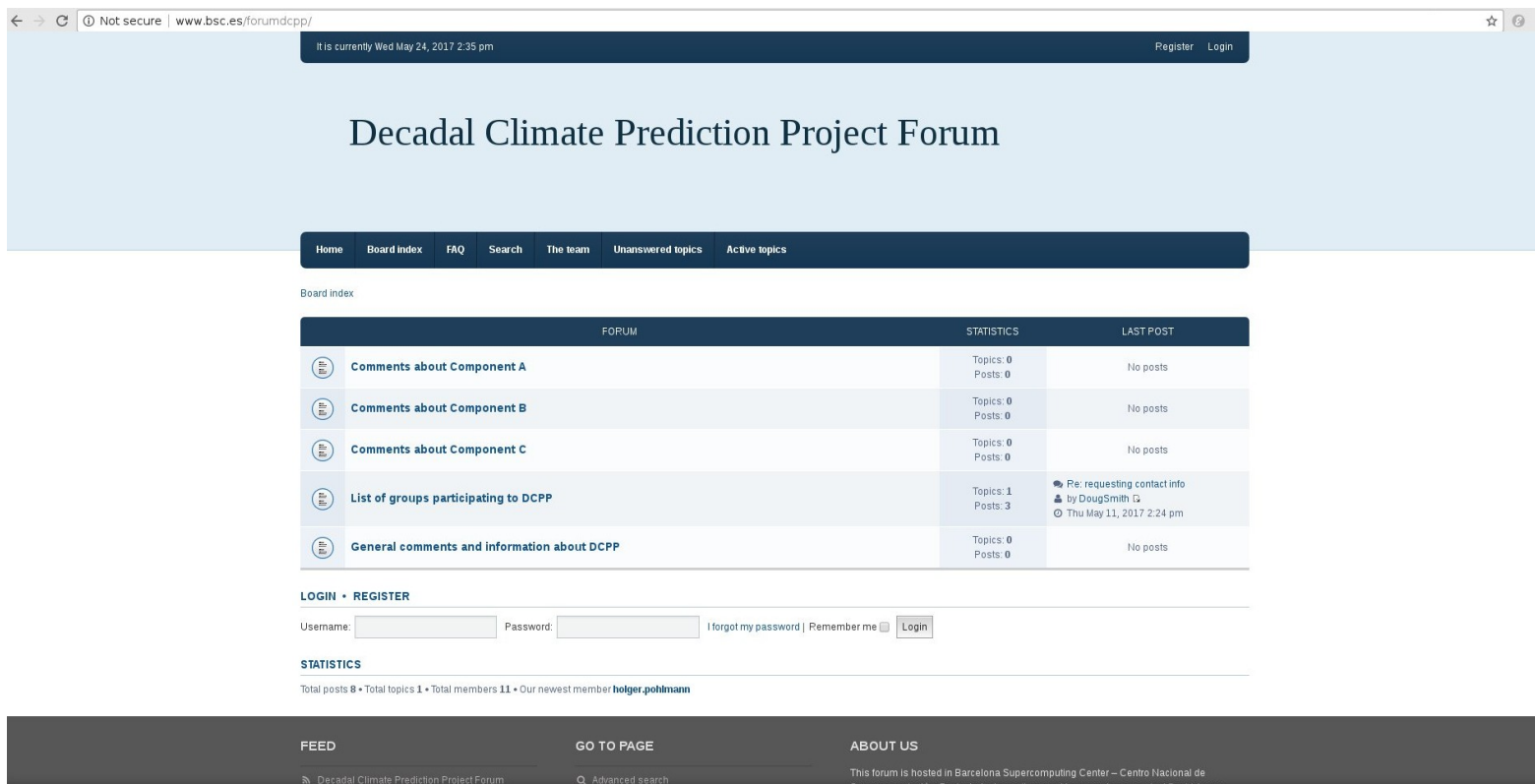
- NEMO 3.6: ORCA025L75-LIM3
- IFS 36r4: T511L91
- Version 3.2.2








- Initial Conditions:
  - prepared by BSC (atmosphere, ocean, sea ice)
  - for all years 1960-present
  - 4 start dates : **November**, February, May, August
- Component A : Decadal hindcasts (6000 years)
  - Every year from 1960-present
  - Starting in November of every year
  - 5 members, extended to 10
  - 5 year predictions, extended to 10 years
- Component B : Semi-operational decadal forecast (100 years)
  - 10 years x 10 members

- Component C - Volcano effects on decadal prediction (M. Menegoz)
- Component C - Idealized impact of AMV/Pacemaker experiments, also for PRIMAVERA (R. Bolbao)
- Carbon cycle :
  - LPJ-Guess for seasonal-to-decadal prediction of fire risk (E. Tourigny)
  - PISCES for ocean CO<sub>2</sub> uptake (V. Sicardi, R. Bernardello)
- “Extra” seasonal prediction hindcasts
  - Use the first months of the decadal runs initialized in November
  - Run short (4 month) predictions initialized in February, May, August
- High Resolution Hindcasts (optional, 3000 years)
  - 5 members, IF we obtain the hours from PRACE (as part of ENES) and only after we have completed everything else (HiResMIP and DCPP standard)

BSC hosts the DCPD web forum. Any discussion (either scientific or data related) should be made through this channel: <http://bsc.es/forumdcpd>



The screenshot shows the Decadal Climate Prediction Project Forum website. The browser address bar indicates the URL is [www.bsc.es/forumdcpd/](http://www.bsc.es/forumdcpd/). The page title is "Decadal Climate Prediction Project Forum". The navigation bar includes links for Home, Board index, FAQ, Search, The team, Unanswered topics, and Active topics. The main content area displays a "Board index" table with the following data:

FORUM	STATISTICS	LAST POST
 <b>Comments about Component A</b>	Topics: 0 Posts: 0	No posts
 <b>Comments about Component B</b>	Topics: 0 Posts: 0	No posts
 <b>Comments about Component C</b>	Topics: 0 Posts: 0	No posts
 <b>List of groups participating to DCPD</b>	Topics: 1 Posts: 3	Re: requesting contact info by DougSmith Thu May 11, 2017 2:24 pm
 <b>General comments and information about DCPD</b>	Topics: 0 Posts: 0	No posts

Below the table, there is a "LOGIN • REGISTER" section with fields for Username and Password, and a "Login" button. A "STATISTICS" section at the bottom shows: "Total posts 8 • Total topics 1 • Total members 11 • Our newest member [holger.pohlmann](#)". The footer contains links for "FEED", "GO TO PAGE", and "ABOUT US".



## DCPP Years simulated: 6200 (including VolMIP)

	Low* estimation	High* estimation
Volume per year simulated (GB)	1.3	3.9
Total volume expected (TB)	8	23.8

## PRIMAVERA Years simulated: 200

	Low* estimation	High* estimation
Volume per year simulated (GB)	1721	2755.8
Total volume expected (TB)	344	551.2

Low = only P1 monthly variables

High = P1-P2 variables

- CMORization will be done “online” (on HPC) with the ece2cmor3 tool (see Gijs von den Oord’s presentation)
- BSC simulations (DCPP and PRIMAVERA) will be published from the BSC ESGF node, online next week (~500TB of storage booked).
- Question on NEMO output variable names... use the NEMO name or CMOR name ?
  - NEMO name easier to remember
  - CMOR name is the next standard...

nemo	CMOR
runoffs	friver
calving_cea	ficeberg2d
qsr_oce	rsntds
qt_oce	hfds
qsr3d	rsdo

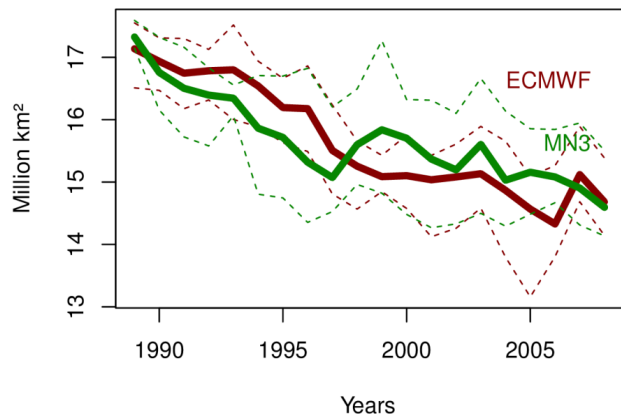
# Reproducibility of EC-Earth

- EC-Earth 3.2beta was tested for its reproducibility using a strict protocol developed at BSC
- Changing the platform from MareNostrum3 to ECMWF does not seem to affect the climate of the model

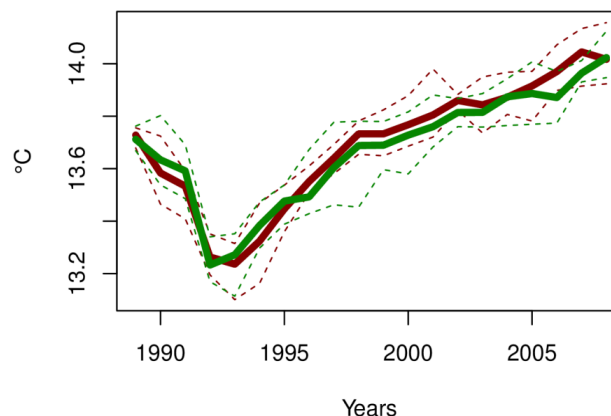
François  
Massonnet  
(UCL/BSC)  
M. Menegoz  
and M.  
Acosta  
(BSC)

☾ This is quite good news, and also indicates that the previous version (EC-Earth 3.1) was probably largely bugged, since this version showed major irreproducibility under the same protocol.

Antarctic sea ice extent sept.



Global mean temperature



- Recent progress by other groups ?
- Plans for climate prediction experiments ?
- Using a workflow manager for climate prediction experiments
- Generation of atmospheric ICs.
- DCPD
  - Partners and workload sharing
  - 3.2.x releases and tuning strategy
  - Output variables



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# Thank you!

For further information please contact  
[etienne.tourigny@bsc.es](mailto:etienne.tourigny@bsc.es)

- **Priority levels:**
  - Make sure that the basic variables that allow the forecast quality analysis & drift understanding are kept (no model level data because of cpu+space)
  - Priority 1 : all
  - Priority 2 : if not too prohibitive (cpu, space)
  - Priority 3 : those of interest to us

# The EC-Earth forecast system



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EXCELENCIA  
SEVERO  
OCHOA

- 20 individual, 4-7 month climate predictions (May-August)
- init. conditions Atmosphere, Ice and Ocean Reanalyses
- init. soil conditions from climatology OR ERA-Land

4 months

10 Members



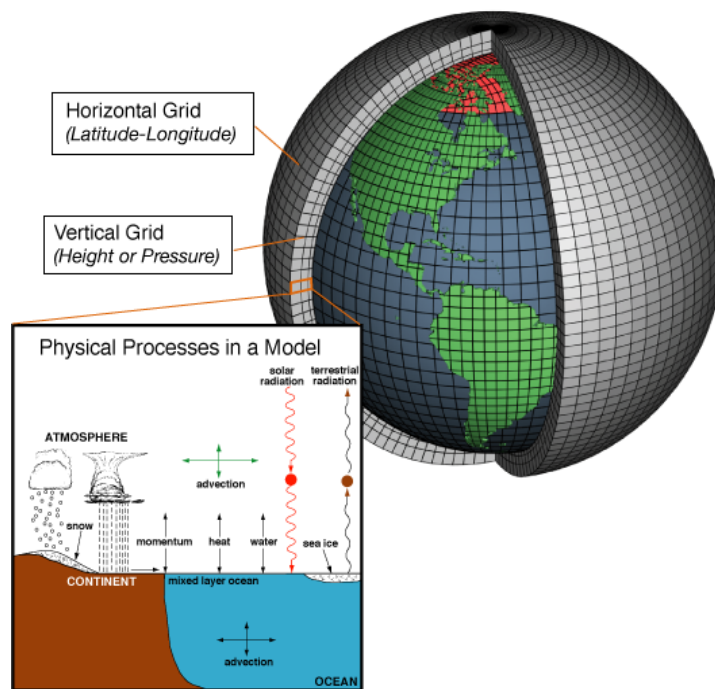
Atmosphere  
Reanalysis  
(ERA-Interim)

Ice  
Reanalysis  
(IC3/BSC)

Land reanalysis  
(ERA-Land)

Ocean reanalysis  
(ECMWF S4)

## EC-Earth coupled model



- T255L91/ORCA1L75
  - Runs in seasonal prediction mode
  - Stratospheric aerosols are being added (M. Ménégoz)
- T511L91/ORCA025L75
  - Fixed compatibility issues (see portal): bathymetry, closed seas, ...
  - Solved numerical instabilities from sea-ice conditions
- PRIMAVERA & HighResMIP output: ongoing (E. Tourigny)
- DCPP : awaiting for EC-Earth version (external & internal)
- BSC & SMHI : MetOffice decadal semi-operational experiment
- Initial Conditions available for climate prediction runs
- Reproducibility tests are underway (Massonnet, Ménégoz, Acosta)
- More in other EC-Earth meeting sessions



- 1) Generation of in-home **sea ice reconstruction** / reanalyzes – **data assimilation techniques** to exploit existing atmospheric and oceanic reanalyzes – development of initialization methods (anomaly versus full-field)
- 2) **Analyses of mechanisms** leading to model bias and development of bias correction techniques accounting for sensitivity of bias to prediction start date
- 3) **Improvement of forecast systems** through better process representation : inclusion of new parameterizations, new model components, high resolution, parameter calibration
- 4) **Identifying sources of skill** such as soil moisture, sea ice thickness, aerosols, biogeochemistry through multi-faceted forecast quality assessment and sensitivity experiments
- 5) Development of reliable techniques for attribution of extreme events, analysis of case studies : 2014 Antarctic sea ice maximum, 2010 heat wave
- 6) Dissemination : Tropical cyclone damages : **hosting of an operational website for the next hurricane season** gathering predictions from all existing centers

- Atmosphere:

- Atmospheric initial conditions generated using FULLPOS for three different resolutions of IFS. FULLPOS conducts a physical interpolation using the model executable and therefore ensures little model drift.
- The initial conditions are prepared for periods:
  - 1960 - 2015 using ERA-40 (1960-1978)
  - ERA-Interim (1979-2015)
  - ERA-Land (1979-2015) - forced by GPCP, replaces surface model fields
- 10-member (SST perturbation), Start dates each year in February, May, August, November
- T511L91 & T255L91 resolutions
- **We can produce more on demand!!!**

- Ocean:
  - ORAS4 interpolated/extrapolated 5-member restarts in the configuration ORCA1L75 covering the 1958-2013 period, at ECFS `ec:/c3y/restarts_ORAS4`
  - Many more available, and more can be produced easily
- Sea Ice:
  - 5-member ORCA1 reconstruction covering the 1958-2006 period = i056 at ECFS `ec:/c3y/restarts_i056`
  - 5-member ORCA1 reconstruction covering the 1979-present period = i057 at ECFS `ec:/c3y/restarts_i057`
  - 1-member ORCA025 reconstructions covering the 1958-2006 period = m063 at ECFS `ec:/c3n/restarts_m063`
  - 1-member ORCA1 reconstruction covering the 1958-2015 period = a05p
  - 24-member ORCA1 reconstructions with sea ice data assimilation (done using NEMO only), covering 1979-1999 (still ongoing): a0a9
  - 24-member ORCA1 reconstructions with sea ice data assimilation (done using EC-Earth), covering 1993-1995 (still ongoing, to be updated because major bug was found, ticket 289 on this portal) = a09p